(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 416 943 A2**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number: 90309829.1

(22) Date of filing: 07.09.90

(51) Int. Cl.5: G06F 11/20

(30) Priority: 08.09.89 US 404748

(43) Date of publication of application:
13.03.91 Bulletin 91/11

(84) Designated Contracting States:
BE DE FR GB IT NL

(71) Applicant: HONEYWELL INC.
Honeywell Plaza
Minneapolis Minnesota 55408(US)

(72) Inventor: Massey, W Russell, Jr.
46 Coral Lane, Levittown
Pennsylvania 19055(US)
Inventor: McLaughlin, Paul F.
2821 Valley Woods Road
Hatfield, Pennsylvania 1944(US)
Inventor: Drobish, Renee
1720 Bantry Dr.
Dresher, Pennsylvania 1944(US)

(74) Representative: Fox-Male, Nicholas Vincent Humbert
Honeywell Control Systems Limited Charles Square
Bracknell Berkshire RG12 1EB(GB)

(54) **Method for controlling failover between redundant network interface modules.**

(57) A method by which redundant network interface modules (NIM)s interconnecting the communication buses of two local area networks communicate with one another at predetermined time intervals over the communication buses of both networks. One of the redundant pair of NIMs is designated as the primary and the other as the secondary. Contents of the information communicated between the NIMs over the communication bus of the first network includes the status of the transmitting NIMs ability to communicate with the second network and the information communicated between the NIMs over the communication bus of the second network includes the status of the transmitting NIM's ability to communicate with the first network. Based on the information exchanged, the failure of the NIMs to communicate as scheduled, and the internal status of each NIM as understood by that NIM, the NIM decide when failover from the primary NIM to the secondary NIM occurs.

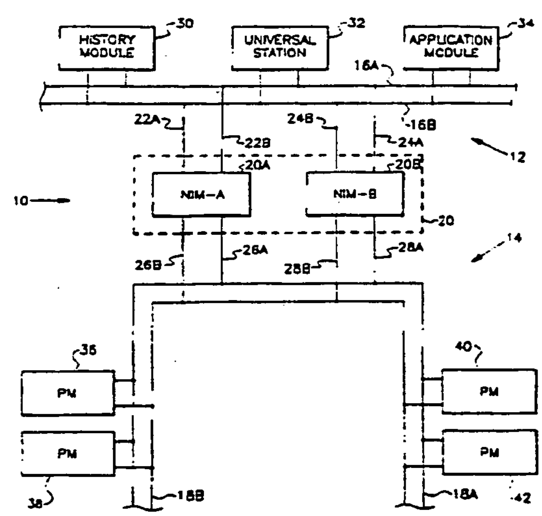

Fig. 1

EP 0 416 943 A2

METHOD FOR CONTROLLING FAILOVER BETWEEN REDUNDANT NETWORK INTERFACE MODULES

CROSS-REFERENCE TO RELATED APPLICATIONS

The following copending patent applications relate to the invention of the present application and are incorporated herein by reference:

A. "Method for Control Data Base Tracking in a Redundant Processor" by P. McLaughlin et al, Serial No. 07/299,859, filed January 23, 1989; and

B. "Apparatus for Providing a Universal Interface to a Process Control System" by A. J. Hahn et al, Serial NO. , filed .

All of the foregoing are assigned to the same assignee.

BACKGROUND OF THE INVENTION

(1) Field of the Invention:

This invention is in the field of methods by which the primary and secondary network interface modules determine their respective status and that of the networks with which they communicate to determine when the primary module shall failover in deference to the secondary and in which the secondary module determines that the primary module has failed in order to assume the role of the primary module.

(2) Description of the Prior Art:

Process control systems which include a hierarchy of local area networks (LAN)s have been developed. An example of such a system is described and claimed in U. Patent No. 4,607,256, which issued to Russel A. Henzel on August 18, 1986. Another such system is illustrated and described in the cross-referenced application entitled "Apparatus for Providing a Universal Interface to a Process Control System" the disclosure of which is incorporated by reference into this application.

In such systems, network interface modules (NIM)s provide communication and data translation capabilities so that modules of the two networks interconnects by a NIM can communicate. The reliability and fault tolerance of process control systems are significantly increased by incorporating in each network a standby, backup, secondary, or redundant module for each of the operating modules of each network, particularly, the NIMs interconnecting the networks, as well as by providing redundant cables over which the modules of each network communicate. Because of the importance of the functions performed by NIMs, providing each NIM of a process control system with a secondary or back up has a high priority. However, there is a need for an improved method by which a primary NIM and secondary NIM of a redundant pair of NIMs in such a system communicate, and the information communicated so that both NIMs have the capability of knowing each others status and of determining, or of controlling, when the secondary NIM will take over the function of the primary NIM; or, stated another way, when the primary NIM will failover to the secondary NIM.

SUMMARY OF THE INVENTION

The present invention provides a method for communicating the respective status of redundant network interface modules (NIM)s between the modules and for controlling failover between the (NIM)s, one of which is designated as the primary NIM and the other as the secondary NIM. The NIMs are connected between the communication media of two local area networks (LAN)s so that the primary NIM can provide communication and data translation between the networks as required so that modules of one network can communicate with modules on the other.The secondary NIM of the redundant pair is available to provide the functions of the primary whenever failure of the primary NIM or failover of the primary NIM to the secondary NIM occurs. The primary and secondary NIMs communicate with each other at regular time intervals over the communication buses of both networks. The information communicated is in the form of messages, more accurately status messages, which include the status of the networks interconnected by the NIMs as perceived by each. The status messages transmitted by each MIN to the other over the communication bus of the first network includes the status of the NIM transmitting the information, the status of the second network as perceived by the transmitting NIM, and other information or data as required. The status messages transmitted by each NIM to the other over the communication bus of the second network include the status of the NIM transmitting the information, the status of the first network as perceived by the transmitting NIM as well as other information, or data, as required.

Communication of the NIMs with one of the networks, such as the first, will take priority over communication with the second for reasons explained later. Some examples of the conditions resulting in failover of the primary NIM to the secondary NIM are: the primary NIM crashes, or fails; the primary NIM is unable to communicate with the first network and the secondary can; the primary NIM is unable to communicate with the second network, but otherwise is functioning properly, and the secondary NIM can communicate with both the first and second networks and the secondary NIM is otherwise functioning properly. Failover of the primary NIM to the secondary NIM will not occur if the secondary NIM is unable to communicate with either the first or second network, or if the secondary NIM has an internal problem which prevents its proper operation, such as a hardware or software failure which has caused the secondary NIM to perform improperly, or to crash.

It is therefore an object of this invention to provide an improved method by which redundant network interface modules interconnecting the communication buses of two local area networks determine when the primary NIM shall failover to the secondary NIM based on information exchanged between the two modules over the media of the two networks.

It is another object of this invention to provide an improved method by which redundant network interface modules interconnecting the communication buses of two local area networks determine when the primary shall fail over to the secondary without requiring any dedicated redundancy hardware.

It is still another object of this invention to provide an improved method for controlling failover of a primary network interface module to the secondary network interface module in a process control system.

It is yet another object of this invention to provide an improved method for controlling failover of a primary network interface module to the secondary network module in a process control system within a predetermined period of time after the occurrence of a fault causing failover to prevent interrupting the process being controlled by the system.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the invention will be readily apparent from the following description of a preferred embodiment thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be affected without departing from the spirit and scope of the novel concepts of the disclosure, and in which:

Fig. 1 is a schematic block diagram of a process control system, the two local area networks of which are provided with redundant network interface modules which practice the method of this invention.

Fig. 2 is a truth table of conditions that determine when failover of the primary NIM to the secondary NIM occurs, when the secondary NIM terminates operation, and when no action takes place.

DETAILED DESCRIPTION

In Figure 1, process control system 10 includes local control network (LCN) 12, only a portion of which is illustrated, and universal control network (UCN) 14. LCN 12 includes a communication bus 16, which in the preferred embodiment comprises redundant coaxial cables 16A and 16B, and UCN also includes a communication bus 18 which in the preferred embodiment also comprises redundant coaxial cables 18A and 18B. Communication between LCN 12 and UCN 14 is provided by redundant network interface modules (NIM)s 20, which includes a pair of NIMs, 20A and 20B, with only one of the NIMs, such as NIM 20A providing such function as well as a data translation function at a given period of time. Under such circumstances, NIM-A is designated as the primary and NIM-B 20B which has the same capabilities as NIM 20A, is designated as the secondary NIM since NIM-B is the backup for NIM-A 20A. NIM-A is directly connected to dual redundant cables 16A and 16B by redundant connectors 22A and 22B, and NIM-B is directly connected to cables 16A and 16B by connectors 24A and 24B. NIMs 20, in the preferred embodiment, are connected to redundant cables 18A and 18-B of UCN 14, by drop cables 26A and 26B for NIM-A and drop cables 28A and 28B for NIM-B.

The modules of LCN illustrated in Fig. 1 include a history module 30, a universal operator station module 32 and an application module 34. Universal operator station module 32 is the work station for one or more plant operators and provides the interface between the plant operator, or operators, and the process or processes of a plant for which the operators are responsible and which processes they monitor and control through the facilities and information provided by control system 10. For a more detailed description of LCN 12 and of modules 30, 32, and 34 as well as other modules of LCN 12 which are not illustrated, refer-

ence is made to the teaching of U.S. Patent 4,607,256.

UCN 14 is provided with process manager modules (PM)s 36, 38, 40, and 42. For a more complete description of the the structure and functions of NIMs 20 and PM modules 36, 38, 40, and 42 reference is made to the applications more completely identified in the section of this application entitled Cross-Reference to Related Patent Applications. In the preferred embodiment, PM modules 36, 38, 40, and 42 provide control functions and also function as network interface modules between UCN 14 and input output networks which include input output (IO) modules. The IO modules which are not not illustrated translate analog or digital input data produced by devices such as valves, pressure switches, pressure gauges, thermocouples, and the like into signals compatible to a process module such as PM 36, and translate signals produced by a process modules such as PM 36 to analog or digital output signals compatible to such devices.

In the preferred embodiment, both LCN 12 and UCN 14 are token passing local area networks (LAN)s typically with each module having a secondary or backup module available to take over for the primary module of a redundant pair. For example in LCN 12 history module 30, universal station module 32 and application module 34 each would normally be provided with a back up module to provide redundancy. LCN 12 may be provided with additional modules of the same or different types as is well known but which are not illustrated. In UCN 14 process modules 36, 38, 40, and 42 would normally be provided with a back up, or standby, module, but such redundant modules are not illustrated in Fig. 1.

The primary function of NIMs 20A and 20B is to provide communications between LCN 12 and UCN 14. The ability of NIMs 20A and 20B, particularly primary NIM-A to communicate with the modules of LCN 12 is a key criteria in determining when primary NIM-A fails over to its secondary NIM-B. The ability of the NIMs 20A and 20B to communicate with LCN 12, particularly with universal station module 32 is because module 32 provides the operators of the process controlled by process control system 10 with a vantage point, or window, to observe, or monitor the process being controlled and how process control system 10 is functioning. More particularly, module 32 provides the operators with information identifying when and where faults occur in the communication media or modules of any of the networks with which universal station module 32 can communicate. Whenever a fault occurs and wherever it occurs, the responsibility of the operators of the process being controlled by system 10 is to take appropriate steps the find and fix the fault as quickly as possible.

Since the communication media of both LCN 12 and UCN 14 are redundant coaxial cables,a fault or faults limited to one of the two cables of either or both networks, will not normally interfere with communications between LCN 12 and UCN 14 because each network has the capability for detecting faults in their redundant communication cables and of switching from the faulty cable ot the redundant, or back up, cable.

In the normal operation of plant control system 10 when all the modules and communication cables of both networks are functioning properly, i.e., without any faults and both the primary NIM-A and the secondary NIM-B are both functioning without fault and no faults are present in any of their drop cables 22, 24, 26, 28. Under such circumstances, secondary NIM-B will transmit a status message to primary NIM-A at least once a second over bus 18 of UCN. This status message includes NIM-B's status, i.e. has NIM-B detected that it has suffered a hardware failure or a software failure; has NIM-B received a status message from primary NIM-A within the past one second over communication bus 18 of UCN 14; and whether secondary NIM-B is receiving signals from other modules of UCN 14. The receipt of such signals signifies that NIM-B can communicate with UCN 14 and that therefore UCN 14 is functioning properly as perceived by NIM-B.

NIM-A transmits at least once a second to NIM-B a status message which includes the hardware and software status of NIM-A; whether NIM-A has received a status message from NIM-B within the previous second over communication bus 18, and whether NIM-A is receiving messages from and transmitting messages to other modules of LCN 12.

Primary NIM-A will transmit a similar status message to NIM-B over the LCN's communication bus 16 except that this message from NIM-A will include information as to whether NIM-A has received a status message from NIM-B within the past one second over communication bus 16 of LCN 12 and the status of UCN 14 as perceived by NIM-A; namely, that NIM-A is communicating with other modules of UCN 14. In addition this status message may include data which NIM-B uses to update its data base so that the data base of NIM-B is substantially the same as that of primary NIM-A. This facilitates NIM-B's being able to assume the functions of NIM-A with a minimum of delay upon a failover. This message sent by NIM-A to NIM-B over bus 16 is sometimes referred to as a redundancy message.

NIM-B will transmit a status message to NIM-A over communication bus 16 including NIM-B's status and that of UCN 14 as perceived by NIM-B

after receiving a predetermined number of redundancy messages from NIM-A over communication bus 16, such as twenty, or at least once every second.

The type of failures, or faults, that can result in NIM-A failing over to NIM-B are: if NIM-A suffers a hardware failure or a software failure; if NIM-B does not receive a status message from NIM-A over buses 16 or 18 of LCN 12 or UCN 14 for 2.5 seconds in the preferred embodiment; if NIM-A is unable to transmit a status message to NIM-B and receive a response from NIM-B over communication bus 16 of LCN 12 within 60 seconds; and NIM-A is unable to communicate with any module of UCN 14 for more than 12 seconds and NIM-B is able to so communicate.

NIM-B is deemed to have a failure if it has a hardware or software fault; if NIM-A does not receive at least one status message from NIM-B over either communication bus 16 of LCN 12 or communication bus 18 of UCN 14 during the previous 60 seconds; or if NIM-B does not receive any status messages from NIM-A over bus 16 of LCN 12 for a period of 2.5 seconds but can receive messages from NIM-A over communication bus 18 of UCN 14.

Figure 3 is a truth table describing the actions taken by NIMs 20A and 20B upon the occurrence of certain conditions to minimize the consequences of such occurrences upon the operation of process control system 10. Row 1 describes the situation when both LCN 12 and UCN 14 are operating properly and neither primary NIM-A nor secondary NIM-B has a hardware or a software failure that prevents it from operating properly.

The situation described in row 2 is one in which primary NIM-A is unable to transmit or receive signals from the communication media 18 of UCN 14. Such a situation can occur if both of its drop cables 26A and 26B have been severed, for example. This occurrence is detected in the following way. NIM-B will transmit to NIM-A over bus 18 of UCN 14 a status message which includes data signifying that NIM-B's status is all right, as is that of LCN 12, and that NIM-B has received a status message from NIM-A over LCN bus 16. Since NIM-A is unable to receive a status message from NIM-B over UCN bus 18 because drop cables 26A and 26B are severed, the failure of NIM-A to receive a status message from NIM-B or to communicate with any other module of UCN 14 for one second results in NIM-A recognizing that it has an UCN failure. NIM-A will transmit a redundancy message to NIM-B over LCN bus 16 at least once a second which message contains data informing NIM-B that NIM-A is isolated from UCN 14. NIM-B will transmit status messages to NIM-A over LCN bus 16 periodically at least once per second. After a 500 msec. delay, NIM-B listens to UCN bus 18 for a message from NIM-A. After five such attempts, NIM-B sends a message to NIM-A over LCN bus 16 commanding NIM-A to terminate operations, and NIM-B takes over the functions of NIM-A. NIM-B will then transmit a message to universal station 32 concerning what has happened so that the operators of the process can take appropriate action to correct the problem, in this case, severed drop cables 26A and 26B.

The conditions described in row 3 are similar to those of row 2 except that secondary NIM-B is unable to communicate over UCN bus 18 because its drop cables 28A and 28B are severed, for example, NIM-B will attempt to transmit a status message over UCN bus 18. NIM-A, since it did not receive a status message from NIM-B within the past second, does not send a status message to NIM-B over UCN bus 18. NIM-A will send a redundancy message to NIM-B over LCN bus 16 informing NIM-B that NIM-A did not receive a status message from NIM-B over bus 18 within the allotted time period, one second. NIM-B will then transmit a status message to NIM-A over LCN bus 16 containing data that NIM-B is unable to communicate with any modules of UCN 14. NIM-A after thirty attempts to receive a message from NIM-B over bus 18, NIM-A will send a message to NIM-B over LCN bus 16 for NIM-B to terminate its operations. NIM-B will in the mean time retry five times to send a status message to NIM-A over bus 18. If NIM-B does not receive a message from NIM-A over bus 18 of UCN 14 after five tries, NIM-B will terminate its operations. Thus, NIM-B under these circumstances is terminated by NIM-A or by its own decision.

The conditions described in row 4 of Fig.3 arise if the connectors 22A 22B of NIM-A fail. The transmission of status messages between NIM-B and NIM-A is as described above with respect to messages transmitted over UCN bus 18. However, when primary NIM-A attempts to send the usual redundancy message to NIM-B after connectors 22A and 22B fail, NIM-A is unable to do so even though it tries at least once every second. Since the redundancy message normally transmitted by NIM-A to NIM-B over LCN bus 16 is not received by NIM-B, NIM-B after 1.7 seconds have elapsed begins transmitting requests to NIM-A over LCN bus 16 for NIM-A to retransmit its redundancy message over bus 16. This request is repeated three times. If no response to its requests are received by NIM-B after 0.8 seconds after the third request was transmitted, NIM-B will have received a status message from NIM-A over bus 18 of UCN that NIM-A is unable to communicate with any of the modules of LCN 12. NIM-B will then send a message to NIM-A over UCN bus 18 telling NIM-A

to terminate operations since it is unable to communicate with LCN 12. Upon the receipt of such a message, NIM-A terminates operation and failover to NIM-B occurs. NIM-B will then notify module 32 of LCN 12 what has occurred.

The circumstances described by row 5 of Fig. 3 occur if the drop cables 24-A and 24-B of NIM-B are cut are severed. When NIM-B transmits its status of LCN 12 to NIM-A over UCN bus 18, it will report that it is unable to communicate with any of the modules of LCN 12. NIM-A will transmit its status message once a second to NIM-B over UCN bus 18 to the effect that in so far as NIM-A is concerned, it can communicate with LCN 12 but not with NIM-B. NIM-A will attempt to transmit its redundancy message to NIM-B over LCN bus 16. Since NIM-B can not receive this message, NIM-B will after 1.7 seconds has elapsed, transmit three requests to NIM-A to the redundancy message over LCN bus 16. NIM-B waits for another 0.8 seconds and if NIM-B does not receive the requested message from NIM-A during that period, NIM-B concludes that it can not communicate with modules on LCN 12 Since NIM-B has received a status message from NIM-A that NIM-A can communicate with the modules of LCN 12, NIM-B terminates its operations. NIM-A then notifies universal station module 32 of LCN 12 of the state of affairs.

The situation described by row 5. of Fig. 3 can also occur if NIM-B should suffer a transmitter failure which is not detected and therefore is not reported as a hardware failure. Under such circumstances, NIM-B will transmit a routine status message to NIM-A including the status of LCN 12 as perceived by NIM-B at least once a second over bus 18. NIM-A will transmit a routine status message to NIM-B including the status of LCN 12 as perceived by NIM-A over bus bus 18. Primary NIM 20A will send a normal redundancy message to secondary NIM 20B over LCN bus 16. While NIM-B can receive this redundancy message from NIM-A, it cannot transmit an appropriate status message to NIM-A over LCN bus 16. If primary NIM 20A does not receive a proper message from NIM-B over LCN bus 16 for 60 seconds, NIM-A will transmit a message to NIM-B over UCN bus 18 telling NIM-B to terminate its operations.

Row 6 describes the action taken by secondary NIM-B if NIM-B is unable to communicate with modules of the LCN. The action taken by NIM-B is to terminate its operation even though NIM-A is unable to communicate properly with modules of UCN 14 and NIM-B can. If both of the NIMs 20A and 20B are unable to communicate with LCN 12, no action is taken, row 7. If primary NIM 20A suffers an LCN failure and secondary NIM 20B an UCN failure, primary NIM 20A fails over to secondary NIM 20B, the situation described in row 8. If both NIM-A and NIM-B have an UCN failure, then no action is taken, row 9. If NIM-B is unable to communicate with modules on either LCN 12 and UCN 14, the situation described in row 10, NIM-B terminates operation. Row 11 describes the situation where NIM-A can communicate only with LCN 12 and NIM-A can not communicate with either the LCN 12 or the UCN 14. Under such circumstances NIM-B terminates its operations. If neither NIM-A nor NIM-B can communicate with with either LCN 12 or UCN 14, then nothing can be done, the situation described by row 12. With respect to the situations described in rows 7, 9 and 12, the most probable cause of both NIMs being unable to communicate with the LCN network, row 7; with the UCN network, row 9; or with both networks, row 12; is that both NIMs have been manually disconnected from the communication cables of the indicated network, or networks. Therefore, the two NIMs wait to be manually reconnected to the communication cables of the LCN, or the UCN, or both, and then resume operations.

Row 13 describes the situation that occurs when NIM-A cannot communicate with either LCN 12 or UCN 14 but NIM-B can communicate with LCN 12 but not UCN 14. If this happens, NIM-A will failover to NIM-B. If NIM-A can not communicate with either LCN 12 or UCN 14, but NIM-A can, then NIM-A will failover to NIM-B, row 14. If NIM-A has a hardware or software failure that causes it to crash, then NIM-A will failover to NIM-B, row 15. If NIM-B has a hardware or software failure that causes NIM-B to crash, NIM-A will stop trying to communicate with NIM-B, row 16.

If both trunk cables 16A and 16B of LCN 12 are severed between NIM 20A and NIM 20B, both NIM-A and NIM-B can communicate with some of the modules of LCN 12 but not with each other over bus 16. When this occurs, NIM-B will transmit the normal status message including the status of LCN 12 to NIM-A over UCN bus 17 at least once a second. NIM-A will transmit the usual status message including the status of LCN 12 to NIM-B over UCN bus 18 at least once a second. NIM-A will transmit the usual redundancy message including the internal status of NIM-A, the status of UCN 14 as perceived by NIM-A and any update data NIM-A has for NIM-B to NIM-B over LCN bus 16. Since NIM-B is unable to receive this message because of the cable fault in communication cables 16A and 16B, NIM-B after 1.7 seconds has elapsed, transmits three requests to NIM-A over LCN bus 16 requesting NIM-A to re-send the redundancy message over LCN cables 16A and 16B. If NIM-B does not receive a redundancy message from NIM-A within 0.8 seconds after transmitting the third request for NIM-A to do so, and based on status

messages from NIM-A received over UCN bus 18, NIM-B determines that NIM-A can communicate with at least some modules of LCN 12. NIM-B then terminates its operation. Row 17 of the truth table of Fig. 3 describes this situation.

From the foregoing, it is believed to be obvious that this invention provides an improved method by which redundant network interface modules interconnecting the communication buses of two local area networks can determine when the primary is to fail over to the secondary based on information exchanged between the modules over the media of the two networks.

Claims

Claim 1. The method by which redundant network modules (NIM)s interconnecting the communication buses of a first and a second local area network communicate with one another over the communication buses of the two networks, the first NIM being designated as the primary and the second NIM being designated as the secondary, the secondary NIM taking over the function of the primary NIM on the occurrence of certain predetermined conditions; comprising the steps of:

the first and second NIMs communicating with each other at predetermined time intervals over the communication buses of both networks, each communication between the NIMs over the communication bus of the first network including the status of the second network as perceived by the NIM transmitting the message and each communication between the NIMs over the communication bus of the second network including the status of the first network as perceived by the NIM transmitting the message;

the primary NIM failing over to the secondary NIM when the primary NIM determines that it is unable to communicate with the first network and the secondary NIM determines that is able to communicate with the first network.

Claim 2. The method of Claim 1 further comprising the step of the secondary NIM terminating its operation if the secondary NIM is unable to communicate with the first network.

Claim 3. The method of Claim 2 in which each communication between the NIMs includes current operating status of the NIM originating such a communication, and further comprising the step of the secondary NIM terminating its operation if the secondary NIM detects it has suffered a hardware or a software failure.

Claim 4. The method of Claim 3 further comprising the step of the primary NIM failing over to the secondary NIM if the primary NIM detects it has suffered a hardware or a software failure.

Claim 5. The method of Claim 4 in which the primary NIM fails over to the secondary NIM without communicating the fact that it has suffered a hardware or a software failure to the secondary NIM.

Claim 6. The method of Claim 5 in which the predetermined time intervals are one second.

Claim 7. The method of Claim 6 in which the first local area network is a token passing network.

Claim 8. The method of Claim 7 in which the second local area network is a token passing network.

Claim 9. In a process control system including an universal control network (UCN) and a local control network (LCN), each being a local area network (LAN) with each network including a plurality of modules, the modules of each network communicating with one another over a communication bus, a pair of network interface modules (NIM)s, one of said NIMs being designated as a primary and the other NIM being designated as a secondary, each of the NIMs being connected between the communication buses of the UCN and the LCN and functioning to provide communication and data translation between the UCN and the LCN, the primary NIM providing such function unless replaced by the secondary NIM, and the secondary NIM being available to provide this function instead of the primary NIM upon the occurrence of predetermined conditions; comprising the steps of:

1, the secondary NIM transmitting to the primary NIM at least once during every first period of time over the UCN's communication bus a status message, the secondary NIM's status message including the current operating status of the secondary NIM and the status of the LCN as determined by the the secondary NIM;

2, the primary NIM transmitting to the secondary NIM at least once during every first period of time over the UCN communication bus a status message, the primary NIM's status message including the current operating status of the primary NIM and the status of the LCN as determined by the the primary NIM;

3, the primary NIM transmitting to the secondary NIM at least once during every first period of time over the LCN communication bus a status message, the primary NIM's status message including current operating status of the primary NIM, of the UCN as determined by the primary NIM, and updating data with which the secondary NIM updates the secondary NIM's data base so that the data base of the secondary NIM substantially matches the data base of the primary NIM;

4, the secondary NIM transmitting to the primary NIM upon receiving a predetermined number of messages from the primary NIM in step 3 con-

taining updating data or during every first period of time, which ever first occurs, over the LCN communication bus a status message, the secondary NIM's status message including the current operating status of the secondary NIM and the current operating status of the UCN as determined by the the secondary NIM;

5, the primary NIM failing over to the secondary NIM if the primary NIM if it is unable to communicate with the LCN, and the secondary NIM is able to communicate with the LCN, and status messages containing such data are received by both NIMs;

6, the secondary NIM terminating its operations if it determines that it is unable to communicate with the LCN;

7, the primary NIM terminating operation of the secondary NIM if the secondary NIM is unable to communicate with one of the LANs;

8, the primary NIM terminating communications with the secondary NIM if the secondary NIM crashes; and

9, the secondary NIM taking over the function of the primary NIM if the primary NIM crashes, if the primary NIM is commanded to shut down by a command from a universal control station module of the first network, or if the primary NIM is powered down;

Claim 10. The method of Claim 9 in which the first period of time is one second.

Claim 11. The method of Claim 10 in which the universal control network is a token passing network.

Claim 12. The method of Claim 11 in which the local control network is a token passing network.

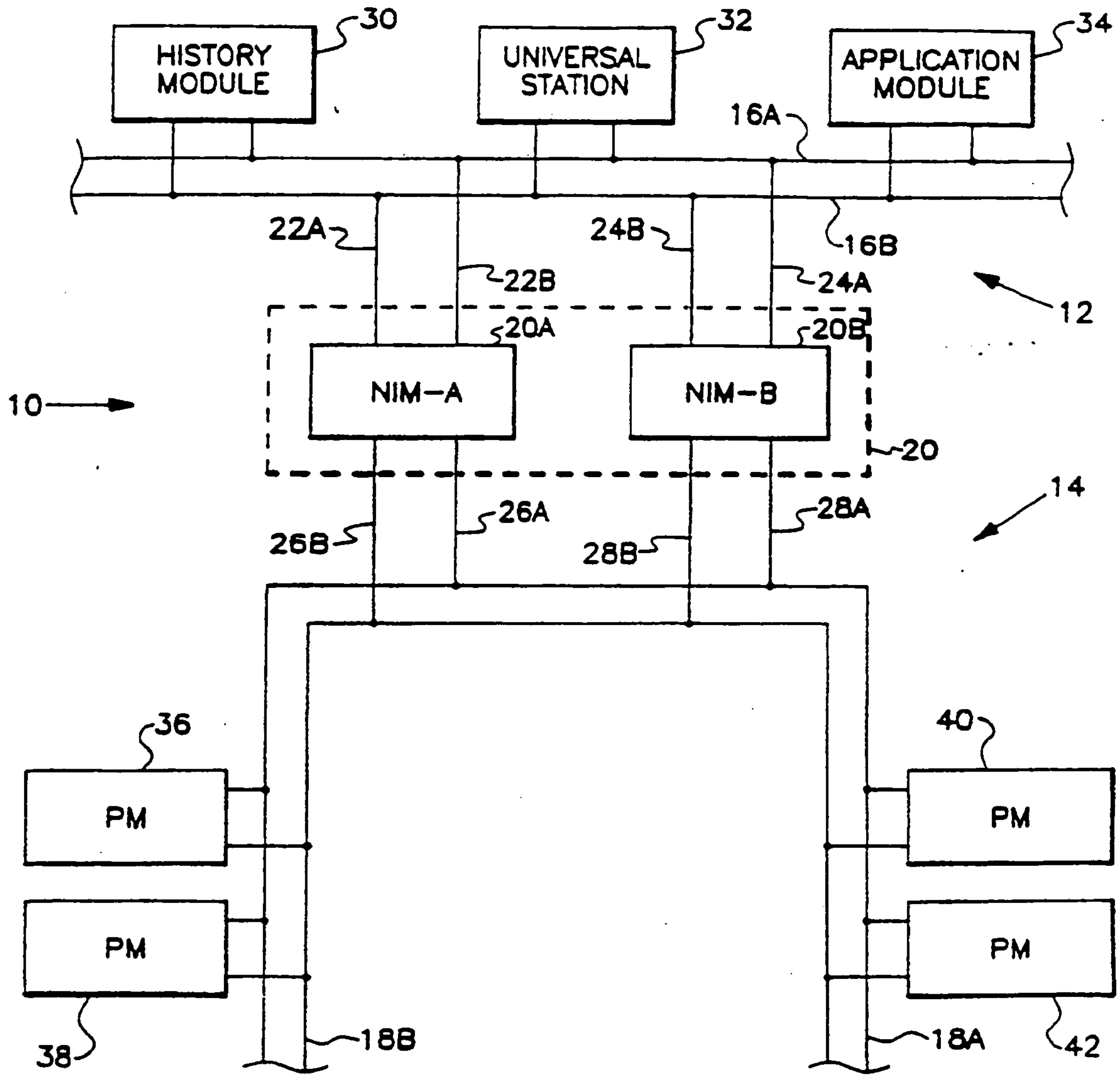
HISTORY MODULE
30
UNIVERSAL STATION
32
APPLICATION MODULE
34
16A
16B
22A
22B
24B
24A
12
20A
20B
NIM–A
NIM–B
10
20
14
26B
26A
28B
28A
36
PM
PM
38
18B
40
PM
PM
42
18A

Fig. 1

		UCN FAIL	UCN OK	LCN FAIL	LCN OK	OUTCOME
1	P		X		X	
	S		X		X	NORMAL OPERATION
2	P	X			X	FAILOVER
	S		X		X	
3	P		X		X	
	S	X			X	SECONDARY TERMINATES
4	P		X	X		FAILOVER
	S		X		X	
5	P		X		X	
	S		X	X		SECONDARY TERMINATES
6	P	X			X	SECONDARY TERMINATES
	S		X	X		
7	P		X	X		NO ACTION
	S		X	X		
8	P		X	X		FAILOVER
	S	X			X	
9	P	X			X	NO ACTION
	S	X			X	
10	P		X		X	SECONDARY TERMINATES
	S	X		X		
11	P	X			X	SECONDARY TERMINATES
	S	X		X		
12	P	X		X		NO ACTION
	S	X		X		
13	P	X		X		FAILOVER
	S	X			X	
14	P	X		X		FAILOVER
	S		X		X	
14	P	X		X		
	S		X		X	FAILOVER
15	PRIMARY CRASH					FAILOVER
16	SECONDARY CRASH					PRIMARY HALTS COMMUNICATIONS WITH SECONDARY
17	P		X		X	PRIMARY AND SECONDARY CAN'T COMMUNICATE ON LCN
	S		X		X	SECONDARY TERMINATES

Fig. 2

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 416 943 A3**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **90309829.1**

(22) Date of filing: **07.09.90**

(51) Int. Cl.5: **G06F 11/20**, H04L 29/14

(30) Priority: **08.09.89 US 404748**

(43) Date of publication of application: **13.03.91 Bulletin 91/11**

(84) Designated Contracting States: **BE DE FR GB IT NL**

(88) Date of deferred publication of the search report: **15.07.92 Bulletin 92/29**

(71) Applicant: **HONEYWELL INC.**
Honeywell Plaza
Minneapolis Minnesota 55408(US)

(72) Inventor: **Massey, W Russell, Jr.**
46 Coral Lane, Levittown
Pennsylvania 19055(US)
Inventor: **McLaughlin, Paul F.**
2821 Valley Woods Road
Hatfield, Pennsylvania 1944(US)
Inventor: **Drobish, Renee**
1720 Bantry Dr.
Dresher, Pennsylvania 1944(US)

(74) Representative: **Fox-Male, Nicholas Vincent Humbert**
Honeywell Control Systems Limited Charles Square
Bracknell Berkshire RG12 1EB(GB)

(54) Method for controlling failover between redundant network interface modules.

(57) A method by which redundant network interface modules (NIM)s interconnecting the communication buses of two local area networks communicate with one another at predetermined time intervals over the communication buses of both networks. One of the redundant pair of NIMs is designated as the primary and the other as the secondary. Contents of the information communicated between the NIMs over the communication bus of the first network includes the status of the transmitting NIMs ability to communicate with the second network and the information communicated between the NIMs over the communication bus of the second network includes the status of the transmitting NIM's ability to communicate with the first network. Based on the information exchanged, the failure of the NIMs to communicate as scheduled, and the internal status of each NIM as understood by that NIM, the NIM decide when failover from the primary NIM to the secondary NIM occurs.

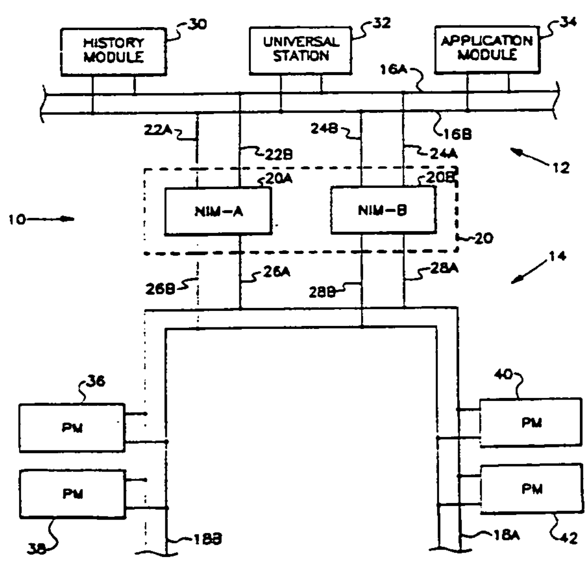

Fig. 1

EP 0 416 943 A3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 9829

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,Y	US-A-4 607 256 (R. A. HENZEL) 19 August 1986 * column 4, line 57 - column 7, line 8 * * column 9, line 37 - column 11, line 6 * * figures 1,2 *	1-4	G06F11/20 H04L29/14
D,A		5-12	

Y	COMPUTER NETWORKS & ISDN SYSTEMS vol. 13, no. 4-5, 1987, AMSTERDAM, NETHERLANDS pages 323 - 332; N. LINGE ET AL: 'A Bridge Protocol for Creating a Spanning Tree Topology within an IEEE 802 Extended LAN Environment' * page 325, column 1 - column 2, line 6 * * page 326, column 2, line 9 - page 328, column 1, line 26 * * figures 3-5 *	1-4	
A		9	

A	US-A-4 831 617 (M. IWASAKI) 16 May 1989 * column 4, line 21 - column 5, line 16 * * claims 1-4; figures 1,4,5 *	1-4,9	
	-----		**TECHNICAL FIELDS SEARCHED (Int. Cl.5)**
			H04L G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	08 MAY 1992	JOHANSSON U.C.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document